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FISHERY RESEARCH

RIVERS AND STREAMS INVESTIGATIONS

Silviculture Practices Impacts on Fish Populations

Job Performance Report
Project F-73-R-12
Subproject IV, Study I

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TABLE OF CONTENTS

Page

ABSTRACT 1

INTRODUCTION 2

OBJECTIVE 2

METHODS 2

RESULTS 2

ACKNOWLEDGEMENTS 6

LITERATURE CITED 7

APPENDIX 8

LIST OF TABLES

Table 1. Variables for streams in Middle Fork Clearwater River drainage, Lochsa and Selway rivers (X-Data available; .-No data) 3

Table 2. Variables for streams in North Fork Clearwater River drainage (X-Data available; .-No data) 4

Table 3. Variables for streams in South Fork Clearwater River drainage (X-Data available; .-No data) 5

JOB PERFORMANCE REPORT

State of: Idaho

Name: Rivers and Streams Investigations

Project: F-73-R-12

Subproject: IV

Title: Silviculture Practices Impacts on Fish Populations

Study: I

Period Covered: March 1, 1989 to February 28, 1990

ABSTRACT

Literature and files were reviewed to gather data used in developing relationships between logging practices and fish populations in Idaho. A bibliography for applicable publications was developed. Data for 55 streams in the Clearwater River drainage are being compiled for eight variables; drainage area, area disturbed, road distance, fish densities, aspect, access, fishing regulations, and geologic type. A relationship between density of roads and cutthroat trout density was found but is too tentative to report.

Authors:

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INTRODUCTION

The State of Idaho and U.S. federal governments have both addressed the need to better define impacts of logging activities on fish populations. The Idaho Forest Practices Act, title 38, chapter 13, Idaho Code, was legislated to implement and enforce laws and rules relating to forest practices on state and private land within the state. On federal forest lands, each National Forest developed a forest plan in accordance with the National Forest Management Act of 1976 and the National Environmental Policy Act of 1969. The forest plans address desired management practices to achieved stated goals for fish populations on federal forests.

Idaho Department of Fish and Game (IDFG) biologists are concerned that these programs do not fully protect aquatic habitat. The thrust of this project is to review pertinent literature and file data that can be used in defining relationships between logging practices and fish populations.

OBJECTIVE

Develop relationships between logging practices and fish populations in Idaho.

METHODS

A literature review was conducted to include only those publications applicable to the project goal. File data from the U.S. Forest Service and IDFG were used in developng a database. Project personnel met with appropriate personnel of IDFG, the U.S. Forest Service, Idaho Department of Environmental Quality, and the University of Idaho Cooperative Fisheries Research Unit to review the project goal and start data assimilation.

RESULTS

Extensive literature reviews by MacDonald et al. (1988) for effects of logging on fish and by Chapman and McLeod (1987) for sedimentation provide excellent resource material background for a study of this type. Rather than duplicate their effort, this project focused on Pacific Northwest regional studies (see Bibliography, Appendix).

We extracted data from files and reports that included information on 55 streams in the Clearwater River drainage (Tables 1-3). Because data is lacking for some variables, relationships between logging practices and fish populations are too tentative to report. Efforts in 1990 will continue to add to the data sets. Data for streams in the Coeur d'Alene River and South Fork Salmon River drainages are sparse and will not be included in this report, but will be developed for final analysis.

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Table 1. Variables for streams in Middle Fork Clearwater River drainage, Lochsa and Selway rivvers (X-Data available; .-No data).

Stream	Area	Km road	Ha disturbed	Fish Density	Aspect	Access	Regulations	Geologic type
Bear Creek	.	.	.	X	X	X	X	.
Big Flat Creek	.	.	.	X	X	X	X	.
Brushy Fork Creek	X	X	.	X	X	X	X	.
Colt Creek	X	X	X	X	X	X	X	.
Crab Creek	X	X	X	X	X	X	X	.
Crooked Fork Creek	.	.	.	X	X	X	X	.
Deep Creek	.	.	.	X	X	X	X	.
Fish Creek	.	.	.	X	X	X	X	.
Hopeful Creek	.	X	X	X	X	X	X	.
Meadow Creek	X	X	X	X	X	X	X	.
Moose Creek	X	X	X	X	X	X	X	.
N.F. Moose Creek	X	X	X	X	X	X	X	.
Old Man Creek	.	.	X	X	X	X	X	.
Otter Creek	X	X	X	X	X	X	X	.
Papoose Creek	X	X	X	X	X	X	X	.
Post Office Creek	X	X	X	X	X	X	X	.
Running Creek	X	X	X	X	X	X	X	.
Squaw Creek	X	X	X	X	X	X	X	.
Three Links Creek	X	X	X	X	X	X	X	.
Warm Springs Creek	.	.	.	X	X	X	X	.
Weir Creek	X	X	X	X	X	X	X	.
White Cap Creek	.	.	.	X	X	X	X	.
White Sand Creek	.	.	.	X	X	X	X	.

TABLE1

Table 2. Variables for streams in North Fork Clearwater River drainage (X-Data available; .-No data).

Stream	Area	Km road	Ha disturbed	Fish density	Aspect	Access	Regulations	Geologic type
Bar Creek	.	.	.	X	X	X	X	.
Bear Creek		X	X	X	X	X	X	.
Cayuse Creek	X	.	.	X	X	X	X	.
Cub Creek	.	.	.	X	X	X	X	.
Death Creek	.	.	.	X	X	X	X	.
Deer Creek	X	X	X	X	X	X	X	.
Doe Creek	.	.	.	X	X	X	X	.
Fisher Creek	.	.	.	X	X	X	X	.
French Creek	X	.	.	X	X	X	X	.
Jackknife Cre	.	.	.	X	X	X	X	.
Kelly Creek	.	.	.	X	X	X	X	.
Lightning Creek	X	X	X	X	X	X	X	.
Little Moose Creek	.	.	.	X	X	X	X	.
Moose Creek	X	X	X	X	X	X	X	.
Osier Creek	X	X	X	X	X	X	X	.
Pack Creek	.	.	.	X	X	X	X	.
Pollock Creek	X	X	X	X	X	X	X	.
Pot Creek	.	.	.	X	X	X	X	.
Rapid Creek	.	.	.	X	X	X	X	.
Rock Creek	X	X	X	X	X	X	X	.
Ruby Creek	.	.	.	X	X	X	X	.
Sprague Creek	.	.	.	X	X	X	X	.
Squaw Creek	.	.	.	X	X	X	X	.
Sugar Creek	X	X	X	X	X	X	X	.
Swamp Creek	X	X	X	X	X	X	X	.

TABLE2

Table 3. Variable data for streams in South Fork Clearwater River drainage (X-data available; .-No data).

Stream	Area	Km road	Ha disturbed	Aspect	Access	Regulations	Geologic type
American River	X	X	X	X	X	X	.
Crooked River	X	X	X	X	X	X	.
E.F. Crooked River	X	.	.	X	X	X	.
Johns Creek	X	X	X	X	X	X	.
Meadow Creek	X	X	X	X	X	X	.
Newsome Creek	X	X	X	X	X	X	.
Red River	X	X	X	X	X	X	.
Relief Creek	X	X	X	X	X	X	.
Tenmile Creek	X	X	X	X	X	X	.

TABLE3

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LITERATURE CITED

Chapman, D.W. and K.P. McLeod. 1987. Development of criteria for sediment in the Northern Rockies ecoregion. Work Assignment 2-73 for Battelle Columbus Laboratories, EPA Contract No. 68-01-6986. Don Chapman Consultants, Boise, Id.

MacDonald, J.S., G. Miller and R.A. Stewart. 1988. The effects of logging, other forest industries and forest management practices on fish: an initial bibliography. Can. Tech. Rep. Fish. Aquat. Sci. 1622:212pp.

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APPENDIX

BIBLIOGRAPHY

Adams, J.N., and R.L. Beschta. 1980. Gravel bed composition in Oregon coastal streams. Canadian Journal of Fisheries and Aquatic Science 37:1514-1521.

Summary: Suggests that stream substrate composition is dynamic, and large fluctuations might not be the result of land use activities.

Berg, L. 1982. The effect of exposure to short-term pulses of suspended sediment on the behavior of juvenile salmonids. In G. Hartman (ed) Proceedings of the Carnation Creek Workshop, a 10-Year Review. Malaspina College, B.C. pp.177-196.

Summary: Short-term exposure to suspended sediment alters behavior of juvenile coho. Breakdown of social organization, change of aggression, increased activity, decrease in feeding ability. Potential for decreased fish production in streams affected by short term pulses of suspended sediment.

Beschta, R.L. 1978. Long-term patterns of sediment production following road construction and logging in the Oregon Coast Range. Water Resources Research 14:1011-1016.

Summary: Suspended sediment production increases in 3 of 8 post-treatment years, following patch-cutting and road building.

Beschta, R.L., and R.L. Taylor. 1988. Stream temperature increases and land use in a forested Oregon watershed. Water Resources Bulletin 24(1):19-25.

Summary: Over a 30-year period, mean stream temperatures increased in relationship to increased forest use (logging, road building).

Bilby, R.E. 1985. Contributions of road surface sediment to a western Washington stream. Forest Science 31(4):827-838.

Summary: Sediment deposition of a gravel-surfaced road did not adversely affect stream water quality in the long run.

Bilby, R.E., and J.W. Ward. 1989. Changes in characteristics and function of woody debris with increasing size of streams in western Washington. Transactions of the American Fisheries Society 118:368-378.

Summary: A reference to characteristics of woody debris of typical streams. Would be useful in rehabilitation of a logged stream.

LOG2

Bilby, R.E., and P.A. Bisson. 1987. Emigration and production of hatchery coho (Oncorhynchus kisutch) stocked in streams draining an old growth and a clear-cut watershed. Canadian Journal of Fisheries and Aquatic Science 44:1397-1407.

Summary: Compared production in two watersheds. Production in the clear-cut drainage was higher. Emigration was lower in the old growth drainage.

Bisson, P.A., and R.E. Bilby. 1982. Avoidance of suspended sediment by juvenile coho salmon. North American Journal of Fisheries Management 2:371-374.

Summary: Juvenile coho exhibited avoidance of suspended sediment relative to their acclimation to background levels of suspended sediment. The juveniles avoided sediment more readily after being subjected to higher background levels of sediment.

Blewett, E. 1984. Salmonid habitat evaluation model. Proceedings of Pacific Northwest Stream Habitat Management Workshop. pp. 301-324.

Summary: A model to evaluate habitat enhancement or deterioration on salmonid production.

Brown, G. W. 1971. Water temperature in small streams as influenced by environmental factors and logging. In J.T. Krygier, and J.D. Hall (eds), Forest Land uses and Stream Environment, Continuing Education Press, Oregon State University. pp. 175-181.

Summary: Shade removal increases radiation loads 6-7 times. Temperature increases can be controlled by leaving buffer strips shaded along stream banks.

Brown, G.W., and J.T. Krygier. 1970. Effects of clear-cutting on stream temperature. Water Resources Research 6:1133-1139.

Summary: Average monthly temperatures increased by 14°F, annual maximum temperatures increased 25°F one year after treatment. Streams with buffer-strips had no change in temperature that could be attributed to clear-cutting.

Brown, G.W., and J.T. Krygier. 1971. Clear-cut logging and sediment production in the Oregon Coast Range. Water Resources Research 7:1189-1198.

Summary: Sediment production doubled after road building, and tripled after burning and clear-cutting on another watershed. Tree felling and yarding did not contribute significantly.

Brusven, M.A., W.R. Meehan, and J.F. Ward. 1986. Summer use of simulated undercut banks by juvenile chinook salmon in an artificial Idaho channel. North American Journal of Fisheries Management 6:32-37.

Summary: Juvenile chinook salmon preferred simulated undercut (shaded) habitat. This was 82% by number, 85% by biomass.

Bryant, M.D. 1983. The role and management of woody debris in west coast salmonid nursery streams. North American Journal of Fisheries Management 3:322-330.

Summary: Evaluation of debris management and importance of debris as salmonid habitat, also logging techniques to minimize impact on riparian areas.

Burns, J.W. 1970. Spawning bed sedimentation studies in northern California streams. California Fish and Game. 56:253-270.

Summary: Spawning bed composition changed after logging, roughly in proportion to amount of stream bank disturbance. Sedimentation was greatest following road building.

Burns, J.W. 1972. Some effects of logging and associated road construction on northern California streams. Transactions of the American Fisheries Society 101:1-17.

Summary: Logging impacts on fisheries. Including sedimentation, fish density, dissolved oxygen, etc.

Chapman, D.W. 1962. Effects of logging upon fish resources of the West Coast. Journal of Forestry 60:533-537.

Summary: A look at research up to 1960 on logging impacts. Also a statement on research and management needs.

Chapman, D.W. 1988. Critical review of variables used to define effects of fines in redds of large salmonids. Transactions of the American Fisheries Society 117:1-21.

Summary: Laboratory experiments haven't accurately duplicated natural conditions. A more minute scale look is needed on the intragravel level.

Chapman, D.W., and K.P. McLeod. 1987. Development of criteria for sediment in the Northern Rockies ecoregion. Work Assignment 2-73, Final Report, Don Chapman Consultants, Boise, ID. 256 pp.

Summary: The most up to date assessment of sedimentation impacts on salmonids. Includes research and management needs and direction.

Coble, D.W. 1961. Influence of water exchange and dissolved oxygen in redds on survival of steelhead trout embryos. Transactions of the American Fisheries Society 90:469-471.

Summary: There is a positive correlation between apparent velocity of groundwater and embryonic survivals and dissolved oxygen levels of gravel water and survivals.

Crouse, M.R., C.A. Callahan, K.W. Malueg, and S.E. Dominguez. 1981. Effects of fine sediments on growth of juvenile coho salmon in laboratory streams. Transactions of the American Fisheries Society 110:281-286.

Summary: Increasing sedimentation suppressed fish production. Juvenile salmonid habitat also needs protection from sedimentation.

Culp, J.M., and R.W. Davies. 1982. Effect of substrate and detritus manipulation on macroinvertebrate density and biomass: implications for forest clear-cutting. In G. Hartman (ed) Proceedings of the Carnation Creek Workshop, a 10-Year Review, Malaspina College., British Columbia. pp. 210-216.

Summary: Some species of aquatic insects (Baetis sp. and chironomids) biomass and density greatly increased with addition of alder detritus. Conversely, hemlock detritus was a poor quality food source. Argument for buffer strips.

Davis, J.C. 1975. Minimal dissolved oxygen requirements of aquatic life with emphasis on Canadian species: a review. Journal of Fisheries Research Board of Canada 32:2295-2332

Summary: A review of oxygen requirements of aquatic life.

de Leeuw, A.W. 1982. The effects of logging on benthic invertebrate stream drift and trout growth rates in two small west coast Vancouver Island streams. In G. Hartman (ed), Proceedings Carnation Creek Workshop, Malaspina College, Nanaimo, British Columbia. pp. 240-256.

Summary: There were no differences in drift rates between logged and =logged drainages, also no difference in drift behavior. Growth rates of rainbow trout fry were higher in logged areas, possibly linked to higher temperatures.

Elliott, S.T. 1986. Reduction of a Dolly Varden population and macrobenthos after removal of logging debris. Transactions of the American Fisheries Society 115:392-400.

Summary: Reduction of both population and biomass occurred after removal of logging debris. Invertebrate drift and macrobenthos density also decreased.

Everest, F.H. 1978. Anadromous fish habitat and forest management - economic considerations. Proceedings of the Annual Conference Western Association of Fish and Wildlife Agencies 58:153-171.

Summary: Fisheries values need to be presented quantitatively to allow a more realistic comparison to timber values. Resulting benefit/cost analysis would make decision making easier.

Everest, F.H., and W.R. Meehan. 1981. Forest management and anadromous fish habitat productivity. Transactions of the North American Wildlife and Natural Resources Conference 46:521-530.

Summary: A review of effects of logging on fishery habitat.

Feller, M.C. 1981. Effects of clearcutting and slashburning on stream temperature in southwestern British Columbia. Water Resources Bulletin 17:863-867.

Summary: Summer temperatures and summer daily temperature fluctuations increased in clear-cut areas and areas clear-cut and slashburned. These changes lasted seven years in the clear-cut watershed and longer in the burned watershed.

Gamblin, M.S. 1988. Taft-Bell sediment and fishery monitoring project: phase I completion report. Bonneville Power Administration DE-AI79-85, BP 23203. 74 pp.

Summary: Sediment analysis suggests that cutthroat spawning success could be depressed, but overyearling survival is not correlated to percent fines. Field analysis suggests that instream habitat availability is the limiting factor for cutthroat populations. Includes population data.

Grant, J.W.A., J. Englert, and B.F. Bietz. 1986. Application of a method for assessing the impact of watershed practices: effects of logging on salmonid standing crops. North American Journal of Fisheries Management 6:24-31.

Summary: Total salmonid biomass decreased in areas clear-cut as compared to un-cut areas. This method used different reaches of the same stream to keep treatment vs. control as similar as possible.

Graynoth, E. 1979. Effects of logging on stream environments and faunas in Nelson. New Zealand Journal Marine and Freshwater Research 13(1):79-109.

Summary: Temperatures increased 6.5°C in summer, decreased 2.5°C in winter, sediment increased, and aquatic insect populations changed greatly. Plecopterans and Ephemeropterans decreased, whereas others increased. Fish populations generally decreased.

LOG2

Gurtz, M.E., J.R. Webster, and J.B. Wallace. 1980. Seston dynamics in southern Appalachian streams: effects of clear-cutting. Canadian Journal of Fisheries and Aquatic Science 37:624-631.

Summary: Suspended particulate matter (seston) increased following clearcutting.

Hall, J.D., and R.L. Lantz. 1969. Effects of logging on the habitat of coho salmon and cutthroat trout in coastal streams. In T.G. Northcote (ed), Symposium on Salmon and Trout in Streams, University of British Columbia, Vancouver. pp.355-375.

Summary: Substantial changes have occurred in temperature and dissolved oxygen in an entirely clear-cut watershed, with no significant changes in patch-cut or un-cut watersheds.

Hartman, G.F., J.C. Scrivener, and T.E. McMahon. 1987. Saying that logging is either "good" or "bad" for fish doesn't tell you how to manage the system. Forestry Chronicle 63:159-165.

Summary: Long-term data set (16 years) evaluating logging impacts. Impacts vary with specific conditions present with each logging activity and which species and life stage of salmonid is present.

Heede, B.H. 1987. Overland flow and sediment delivery five years after timber harvest in a mixed conifer forest, Arizona, U.S.A. Journal of Hydrology 91:205-216

Summary: Sedimentation and overland flow are not significant if ecologically sound logging practices are implemented.

Heifetz, J., M.L. Murphy, and K.V. Koski. 1986. Effects of logging on winter habitat of juvenile salmonids in Alaskan streams. North American Journal of Fisheries Management 6:52-58.

Summary: Comparison of old growth, clear-cut with buffers, and clear-cut to stream bank. Clear-cut without buffers provided the least amount of habitat, and buffered reaches at times produced more cover than old growth reaches.

Hoffman, R.J. 1986. A horizontal intragravel pipe for sampling water quality in salmonid spawning gravel. North American Journal of Fisheries Management 6:445-448.

Summary: This method can more efficiently sample intragravel water and also a larger volume can be sampled.

Hogan, D. 1984. The influence of large organic debris on channel morphology in Queen Charlotte Island streams. Proceedings of the Annual Conference of Western Association of Fish and Wildlife Agencies 64:263-273.

Summary: The effects of different size classes and orientation of organic debris on stream channel morphology.

Hogan, D.L., and M. Church. 1989. Hydraulic geometry in small, coastal streams: progress toward quantification of salmonid habitat. Canadian Journal of Fisheries and Aquatic Science 46:844-852.

Summary: A means to quantify salmonid habitat by mapping streams thoroughly to evaluate logging impacts.

Holtby, B., and C.P. Newcombe. 1982. A preliminary analysis of logging related temperature changes in Carnation Creek, British Columbia. In G. Hartman (ed) Proceedings of the Carnation Creek Workshop, a 10-Year Review, Malaspina College, Nanaimo, B.C. pp.81-99.

Summary: Stream temperatures increased following logging. Temperature impacts on fish are probably mitigated by the cool moist climate of British Columbia. Potential temperature increase can be great.

Holtby, B.L. 1988. Effects of logging on stream temperatures in Carnation Creek, British Columbia, and associated impacts on the coho salmon (Oncorhynchus kisutch). Canadian Journal of Fisheries and Aquatic Science 45:502-515.

Summary: An increase in stream temperature following logging caused coho fry to emerge earlier - lengthening their growing season (6 weeks). Smolt numbers doubled, but early migration resulted in decreased smolt-to-adult survival.

Holtby, B.L., and G.F. Hartman. 1986. Factors limiting production of outmigrant salmonid from Carnation Creek before and after logging. Proceedings of the Annual Conference Western Association of Fish and Wildlife Agencies. 66:68.

Summary: No data, just a statement as to general direction of findings in Carnation Creek.

House, R.A., and P.L. Boehne. 1986. Effects of instream structures on salmonid habitat and populations in Tobe Creek, Oregon. North American Journal of Fisheries Management 6:38-46.

Summary: Habitat was significantly greater (2X the number of pools, and 10X the amount of spawning gravel) in unlogged sections of streams.

Iwanaga, P.M., and J.D. Hall. 1973. Effects of logging on growth of juvenile coho salmon. Environmental Protection Agency, Ecological Research Report, EPA-R3-73-006. 35p.

Summary: Juvenile coho in cooler (control) stream water generally had better growth rates. In the wild state, coho grew at higher rates in clear-cut areas. This may be contributed to a decline in cutthroat or reduced competition.

Johnson, S.L. 1984. Freshwater environmental problems and coho production in Oregon. Oregon Department of Fish and Wildlife, Fisheries Division Informational Report No. 84-11. 31p.

Summary: An historical account of logging impacts on coho salmon in Oregon. Also presents research pertaining to assessing logging impacts.

Johnson, S.W., and J. Heifetz. 1985. Methods for assessing effects of timber harvest on small streams. NOAA Technical Memorandum NOAA-TM-NMFS-F/NWC-73.

Summary: Methods used by Northwest and Alaska Fisheries Center to assess logging impacts.

Johnson, S.W., J. Heifetz, and K.V. Koski. 1986. Effects of logging on the abundance and seasonal distribution of juvenile steelhead in some southeastern Alaska streams. North American Journal of Fisheries Management 6:532-537.

Summary: Fry density initially increased following clear-cutting, but decreased presumably from lack of wintering habitat.

Klassen, H.D., and T.G. Northcote. 1988. Use of gabion weirs to improve spawning habitat for pink salmon in a small logged watershed. North American Journal of Fisheries Management 8:36-44.

Summary: In-stream weirs improve spawning habitat following logging.

Klock, G.O. 1985. Modeling the cumulative effects of forest practices on downstream aquatic ecosystems. Journal of Soil and Water Conservation 40(2):237-241.

Summary: A model to predict downstream effects of multiple management schemes on forested lands.

Lantz, R.L. 1967. An ecological study of the effects of logging on salmonids. 47th Annual Conference Western Association State Game and Fish Commissions Proceedings 1967:323-335.

Summary: Outlines Alsea watershed study and preliminary results indicating logging impacts on habitat.

Lantz, R.L. 1970. Effects of logging on aquatic resources. In H.J. Raymer, H.J. Campbell, and W.C. Lightfoot (eds), Progress in Game and Sport Fishery Research. 1963-1970. Oregon State University. pp.13-16.

Summary: Logging impacts were minimized by inclusion of buffer strips on stream corridors. Stream temperatures increased following clearcutting. Coho seem tolerant of logging impacts. Cutthroat, on the other hand, declined to approximately 25% of pre-logging populations.

Lantz, R.L. 1971. Influence of water temperature on fish survival, growth, and behavior. In J.T. Krygier, and J.D. Hall (eds), Forest Land Uses and Stream Environment, Continuing Education Press, Oregon State University. pp. 182-193.

Summary: A literature review of temperature effects on salmonids prior to 1969. Temperature increases and decreases can cause meristic changes in skeletons of teleosts.

Macdonald, J.S., G. Miller, and R.A. Stewart. 1988. The effects of logging, other forest industries and forest management practices on fish: an initial bibliography. Canadian Technical Report Fisheries Aquatic Science 1622:212 pp.

Summary: An intensive bibliography of over 1,500 scientific titles. Is indexed by geographical region, subject, and study site.

McHenry, M. 1988. Assessing the effects of sediment on chinook salmon eggs. Idaho Clean Water Fall:6-7.

Summary: Chinook survival decreases when fine sediments are 20-30% of total dry weight of substrate.

Megahan, W.F. 1972. Sedimentation in relation to logging activities in the mountains of central Idaho. Proceedings Sediment Yield Workshop, U.S. Agricultural Research Service Report ARS-S-40. pp. 74-82.

Summary: Sedimentation increased from 150-550 times more than undisturbed following logging and road building.

Megahan, W.F. 1980. Effects of silvicultural practices on erosion and sedimentation in the interior west - a case for sediment budgeting. In D.W. Baumgartner (ed), Symposium Proceedings of Intermountain West Watershed Management pp. 169-181.

Summary: Measurement of disturbance impacts by degree of and method of disturbance.

Modde, T., H.G. Drewes, and M.A. Rumble. 1986. Effects of watershed alteration on the brook trout population of a small Black Hills stream. Great Basin Naturalist 46:39-45.

Summary: Brook trout densities were not adversely influenced by landscaping activities (clearcutting), although stream temperature did increase as well as turbidity.

Moffitt, C.M., and T.C. Bjornn. 1984. Fish abundance upstream from Dworshak Dam following exclusion of steelhead trout. Idaho Water and Energy Resources Research Institute, Technical Completion Report 54 pp.

Summary: Resident populations of rainbow and cutthroat aren't utilizing habitat left vacant after exclusion of anadromous steelhead trout. Includes population data.

Moring, J.R. 1981. Changes in populations of reticulate sculpins (Cottus perplexus) after clear-cut logging as indicated by downstream migrants. American Midland Naturalist 105:204-207.

Summary: Sculpin populations decreased following logging. Average length increased due to reduced competition. .

Moring, J.R. 1982. Decrease in stream gravel permeability after clear-cut logging: an indication of intragravel conditions for developing salmonid eggs and alevins. Hydrobiologia 88:295-298.

Summary: Under different logging regimes (un-cut, buffer-cut,clear-cut) stream gravel permeability decreased in relation to intensity of logging regime.

Murphy, M.L., and J.D. Hall. 1981. Varied effects of clear-cut logging on predators and their habitat in small streams of the Cascade Mountains, Oregon. Canadian Journal of Fisheries and Aquatic Science 38:137-145.

Summary: Biomass, density, and species richness of aquatic predators increased with clear-cutting. This is in high gradient streams with canopy removal.

Murphy, M.L., C.P. Hawkins, and N.H. Anderson. 1981. Effects of canopy modification and accumulated sediment on stream communities. Transactions of the American Fisheries Society 110:469-478.

Summary: Increased primary production following clear-cutting masks the detrimental effects of sedimentation.

Murphy, M.L., J. Heifetz, S.W. Johnson, K.V. Koski, and J.F. Thedinga. 1986. Effects of clear-cut logging with and without buffer strips on juvenile salmonids in Alaskan streams. Canadian Journal of Fisheries and Aquatic Science 43:1521-1533.

Summary: Buffer strips protect habitat, allows increased primary production, can increase fry and parr if debris is left in the stream.

Murphy, M.L., K.V. Koski, J. Heifetz, S.W. Johnson, D. Kirchofer, and J.F. Thedinga. 1984. Role of large organic debris as winter habitat for juvenile salmonids in Alaska streams. Proceedings of Annual Conference Western Association of Fish and Wildlife Agencies 64:251-262.

Summary: Large organic debris (LOD) is an important part of salmonid habitat in winter, logging increased coho fry abundance in summer, but fry survivability decreased throughout winter.

Narver, D.W. 1972. A survey of some possible effects of logging on two eastern Vancouver Island streams. Fisheries Research of Board Canada Technical Report No. 323. 55 pp.

Summary: Fish populations were greater in unlogged portions of streams. Fish were generally larger in logged streams. Temperature increased with logging. Banks were eroded and one was wider.

Newbold, J.D., D.C. Erman, and K.B.Roby. 1980. Effects of logging on macroinvertebrates in streams with and without bufferstrips. Canadian Journal of Fisheries and Aquatic Science 37:1076-1085

Summary: Macroinvertebrates increased following logging.

Noel, D.S., C.W. Martin, and C.A. Federer. 1986. Effects of forest clearcutting in New England on stream macroinvertebrates and periphyton. Environmental Management 10:661-670.

Summary: There was 6X increase in periphyton densities following clearcutting. Macroinvertebrates increased 2-4 times also. These increases are believed to be related to higher light levels and increased stream temperatures.

Parker, B.L., K.M. Lee, and F.A. Espinosa Jr. 1989. Lochsa River tributaries sediment and fish monitoring report. Powell Ranger District, Clearwater National Forest. 38 pp.

Summary: Cobble embeddedness as an indicator to population densities. Fish density didn't correlate inversely to the level of disturbance. Embeddedness varies between management regime and habitat type (pool, riffle, run).

Patric, J.H., and G.M. Aubertin. 1977. Long-term effects of repeated logging on an Appalachian stream. Journal of Forestry 75:492-494.

Summary: No detrimental effects of logging on watershed, even following 75 years of intensive forest management. Not conclusive or very comprehensive.

Pella, J.J., and R.T. Myren. 1974. Caveats concerning evaluations of logging on salmon production in southeastern Alaska from biological information. Northwest Science 48:132-144.

Summary: A summary of research needs based on limitations found in current and previous literature.

Peters, G.B., H.J. Dawson, B.F. Hrutfiord, and R.R. Whitney. 1976. Aquaeous leachate from western red cedar: effects on some aquatic organisms. Journal of Fisheries Research Board of Canada 33:2703-2709.

Summary: Aqueous leachate from slash and wood products proved toxic to coho during growth life stages.

Phillips, R.W. 1971. Effects of sediment on the gravel environment and fish production. In J.T. Krygier, and J.D. Hall (eds), Forest Land Uses and Stream Environment, Continuing Education Press, Oregon State University. pp. 64-74.

Summary: This is a review of research dealing with sedimentation up to 1969.

Phillips, R.W., R.L. Lantz, E.W. Claire, and J.R. Moring. 1975. Some effects of gravel mixtures on emergence of coho salmon and steelhead trout fry. Transactions of the American Fisheries Society 104:461-466.

Summary: An inverse relationship was established between quantity of fines and emergent survival. Ninety-six percent coho and 94% steelhead survival in control mixture to 8% coho and 18% steelhead survival in 70% sand.

Platts, W.S. 1970. The effects of logging and road construction on the aquatic habitat of the South Fork Salmon River, Idaho. Western Proceedings Fifth Annual Conference Western Association of State Game and Fish Commissions 50:182-185.

Summary: Historical account of logging impacts on one specific watershed, and research and management concerns in an area highly susceptible to sedimentation.

Platts, W.S., and R.L. Nelson. 1988. Fluctuations in trout populations and their implications for land-use evaluation. North American Journal of Fisheries Management 8:333-345.

Summary: Fisheries are a dynamic resource and fluctuations might not be totally as a result of land use practices. Models haven't incorporated population dynamics.

Platts, W.S., and S.B. Martin. 1980. Livestock grazing and logging effects on trout. Proceedings of Wild Trout II. pp. 34-46

Summary: A general review of detrimental impacts of logging on habitat.

Platts, W.S., and S.B. Martin. 1980. Return of the South Fork Salmon. Idaho Wildlife 2:2-9.

Summary: A popular article on South Fork Salmon recovery after heavy sedimentation from intense logging practices in the "40s"and "50s".

Platts, W.S., M.A. Shirazi, and D.H. Lewis. 1979. Sediment particle sizes used by salmon for spawning with methods for evaluation. U.S. Environmental Protection Agency Environmental Research Laboratory, EPA-600/3-79-043. 33 pp.

Summary: Using "geometric mean particle diameter" as a method of valuating spawning gravel usefulness for chinook. Chinook preferred sediments 7.0 to 20 mm GMPD.

Platts, W.S., R.J. Torquemada, M.L. McHenry, and C.K. Graham. 1989. Changes in salmon spawning and rearing habitat from increased delivery of fine sediment to the South Fork Salmon River, Idaho. Transactions of the American Fisheries Society 118:274-283.

Summary: Fine sediments have recovered from 48% of volume in 1969 to 25.4% in 1985 following a logging moratorium and careful regulation of land use.

Ramberg, L. 1976. Effects of forestry operations on aquatic ecosystems. Ecological Bulletin 21:143-149.

Summary: An overall look at logging impacts. Information from Scandinavian countries and Europe.

Reiser, D.W., and R.G. White. 1988. Effects of two sediment size-classes on survival of steelhead and chinook and salmon eggs. North American Journal of Fisheries Management 8:432-437.

Summary: Lowest survival of eggs was found in fine sediments. Egg survival was positively correlated to intragravel water velocities. Smaller sediments are most detrimental to incubating eggs (<.84mm).

Rice, R.M., F.B. Tilley, and P.A. Datzman. 1979. A watershed's response to logging and roads: South Fork of Caspar Creek, 1967-76. U.S.D.A. Forestry Service, Pacific Southwest Forestry Range and Experimental Station, Research Paper PSW-146. 12 pp.

Summary: Road construction and 4-year post-production contributed 80% more sediment than pre-treatment regression analysis predicted. Three years of logging contributed 275% more sediment than predicted.

Rieman, B.E., and K. Apperson. 1989. Status and analysis of salmonid fisheries: westslope cutthroat trout synopsis and analysis of fishery information. Idaho Department of Fish and Game, Project F-73-R-11, Subproject No II, Job No. 1. 114 pp.

Summary: A review of historic distribution in Idaho and current status. Also includes a cumulative review of literature pertaining to westslope cutthroat.

Ringler, N.H., and J.D. Hall. 1975. Effects of logging on water temperature and dissolved oxygen in spawning beds. Transactions of the American Fisheries Society 104:111-121.

Summary: Stream temperature of intragravel water increased following clear-cut logging, and dissolved oxygen decreased. No serious reduction in coho survival, but cutthroat resident population may have decreased because of logging activities.

Ringler, N.H., and J.D. Hall. 1988. Vertical distribution of sediment and organic debris in coho salmon (Oncorhynchus kisutch) redds in three small Oregon streams. Canadian Journal of Fisheries and Aquatic Science 45:742-747.

Summary: Fine sediment was uppermost in areas of clear- and patch-cuts. Organic debris was nearest the surface in the clear-cut stream.

Rishel, G.B., J.A. Lynch, and E.S. Corbett. 1982. Seasonal stream temperature changes following forest harvesting. Journal of Environmental Quality 11:112-116.

Summary: Maximum stream temperature on a clear-cut forest reached 32°C where temperature only reached 22°C on untreated adjacent reaches of stream. A buffer-cut area recorded maximum temperature at 23°C.

Rothacher, J. 1971. Regimes of streamflow and their modification by logging, In J.T. Krygier, and J.D. Hall (eds), Forest Land Uses and Stream Environment, Continuing Education Press, Oregon State University. pp. 175-181.

Summary: Logging and burning on an experimental watershed increased annual yields of streamwater by 18 inches.

Scrivener, J.C., and B.C. Andersen. 1984. Logging impacts and some mechanism that determines the size of spring and summer populations of coho salmon fry (Oncorhynchus kisutch) in Carnation Creek, British Columbia. Canadian Journal of Fisheries and Aquatic Science 41:1097-1105.

Summary: Fry emerged up to six weeks early and migrated sooner than expected. Growth is density dependent.

Scrivener, J.C., and M.J. Brownlee. 1982. An analysis of the Carnation Creek gravel-quality data, 1973 to 1981. In G. Hartman (ed) Proceedings of the Carnation Creek Workshop, a 10-year Review, Malaspina College, Nanaimo, B.C. pp. 154-174.

Summary: Survival from egg to fry coho and chum was noted. Fines increased over pre-logging levels. Intergravel permeability and dissolved oxygen decreased following logging.

Scrivener, J.C., and M.J. Brownlee. 1989. Effects of forest harvesting on spawning gravel and incubation survival of chum (Oncorhynchus keta) and coho salmon (0. kisutch) in Carnation Creek, British Columbia. Canadian Journal of Fisheries and Aquatic Science 46:681-696.

Summary: Survival to emergence of coho and chum declined from 29.1% to 16.4% and 22.2% to 11.5%, respectively, following logging.

Shirazi, M.A., D.H. Lewis, and W.K. Seim. 1979. Monitoring spawning gravel in managed forested watersheds. A proposed procedure. U.S. Environmental Protection Agency, Environmental Research Laboratory, EPA-600/3-79-014. 14 pp.

Summary: Describes methods to best qualify and monitor spawning gravel. This is a trade-off between acceptable reliability and minimum number of samples.

Shortreed, K.S., and J.G. Stockner. 1983. Periphyton biomass and species composition in a coastal rainforest stream in British Columbia: effects of environmental changes caused by logging. Canadian Journal of Fisheries and Aquatic Science 40:1887-1895.

Summary: Stream temperatures increased 2-3°C following logging, and periphyton biomass and accumulation rate increased following logging due to 100% increase in light intensity.

Shumway, D.L., C.E. Warren, and P. Doudoroff. 1964. Influence of oxygen concentration and water movement on the growth of steelhead trout and coho salmon embryos. Transactions of the American Fisheries Society 93:342-356.

Summary: Fry from embryos reared at low and intermediate oxygen concentrations were smaller and hatched later than embryos reared at higher concentrations of dissolved oxygen. Reduced water velocities resulted in smaller hatching fry.

Skille, J. 1988. Stream sediment inventory of the Little North Fork Clearwater River. Preliminary Progress Report, Idaho Department of Environmental Quality. 9 pp.

Summary: Cobble embeddedness measures of the LNFCR and tributaries tend to indicate that logging impacts are potentially effecting fish populations. Embeddedness is lower in pristine sections of stream reaches.

Smith, C.E., W.P. Dwyer, and R.G. Piper. 1983. Effect of water temperature on egg quality of cutthroat. Progressive Fish Culturist 45:176-178.

Summary: Females held in creek water with fluctuating temperature (2-10°C) had significantly better eggs that those held in constant temperature spring water (10°C).

Stednick, J.D., L.N. Tripp, and R.J. McDonald. 1982. Slash burning effects on soil and water chemistry in southeastern Alaska. Journal of Soil and Water Conservation, March-April 1982:126-128.

Summary: Timber harvesting followed by slash burning in southeastern Alaska did not significantly affect soil or water resources. Optical turbidity (NTU's) never reached Alaska's water quality standard of 5.0 NTU's for potable water.

Stowell, R., A. Espinosa, T.C. Bjornn, W.S. Platts, D.C. Burns, and J.S. Irving. 1983. Guide for predicting salmonid response to sediment yields in Idaho batholith watersheds. U.S.D.A. Forest Service Northwestern Regional Intermountain Region. 95 pp.

Summary: A model to predict salmonid response to sediment yield. This model is limited to batholith soil types.

Suanders, J.W., and M.W. Smith. 1965. Changes in a stream population of trout associated with increased silt. Journal of Fisheries Research Board of Canada 22:395-404.

Summary: Low standing crops of brook trout were closely associated with sedimentation. Trout populations adapted to sedimentation and increased following scouring.

Tebo, L.B. Jr. 1957. Effects of siltation on trout streams. Society for American Forestry 1956:198-202.

Summary: A statement of logging impacts from cited information. Reduction of aquatic invertebrates following logging, siltation affecting water quality, etc.

Thedinga, J.F., M.L. Murphy, J. Heifetz, K.V. Koski, and S.W. Johnson. 1989. Effects of logging on size and age composition of juvenile coho salmon (Oncorhynchus kisutch) and density of presmolts in southeast Alaska streams. Canadian Journal of Fisheries and Aquatic Science 46:1383-1391.

Summary: Coho fry increased following clear-cutting, as was measured by survival to winter. Fry being larger and earlier emergence from egg is attributed to higher stream temperature.

Thurow, R. 1987. Evaluation of the South Fork Salmon River steelhead trout fishery restoration program. Completion report. Idaho Fish and Game, Contribution No. 14-16-0001-86505. 154 pp.

Summary: A population evaluation of trout and salmon in South Fork Salmon River. Includes population data.

Tripp, D.B., and V.A. Poulin. 1986. The effects of mass wasting on juvenile fish habitats in streams on the Queen Charlotte Islands. Ministry of Forests and Lands, Land Management Report No. 45. 48 pp.

Summary: Mass wasting causes stream torrents in 1st and 2nd order perennial streams that substantially reduces quantity and quality of rearing habitat. This was greatest in reaches >7% gradient.

Troendle, C.A., and R.M.King. 1987. The effect of partial and clearcutting on streamflow at Deadhorse Creek, Colorado. Journal of Hydrology 90:145-157.

Summary: Water yield on a partial cut area was not significantly different from an adjacent clear-cut.

Tschaplinski, P.J., and G.F. Hartman. 1982. Winter distribution of juvenile coho salmon (Oncorhynchus kisutch) in Carnation Creek and some implication to overwinter survival. In G. Hartman fed), Proceedings of the Carnation Creek Workshop, Malaspina College, Nanaimo B.C. pp. 273-286.

Summary: Logging has not adversely affected coho survival, nor their ability to overwinter.

Tschaplinski, P.J., and G.F. Hartman. 1983. Winter distribution of juvenile coho salmon (Oncorhynchus kisutch) before and after logging in Carnation Creek, British Columbia, and some implications for overwinter survival. Canadian Journal of Fisheries and Aquatic Science 40:452-461.

Summary: Logging has not adversely affected coho survival, nor their ability to overwinter.

Ward, M.G., and N.G. Aumen. 1986. Woody debris as a source of fine particulate organic matter in coniferous forest stream ecosystem. Canadian Journal of Fisheries and Aquatic Science 43:1635-1642.

Summary: Organic debris, both large and small, and it's contribution to sediment budgets.

Wesche, T.A., D. W. Reiser, V.R. Hasfurther, W.A. Hubert, and Q.D. Skinner. 1989. New technique for measuring fine sediment in streams. North American Journal of Fisheries Management 9:234-238.

Summary: Use of a modified Whitlock-Vibert box to collect sediment. Boxes can be used as an alternative to freeze core sampling.

Wilzbach, M.A., K.W. Cummins, and J.D. Hall. 1986. Influence of habitat . manipulations on interactions between cutthroat and invertebrate drift. Ecology. 67:898-911.

Summary: Cutthroat foraged more efficiently, and growth rates increased more in pools draining logged watersheds. This is attributed to the amount of overhead shading. It appears that habitat features in logged streams favor greater foraging success.

Wolfe, M.D., and J.W. Williams. 1986. Rates of landsliding as impacted by timber management in northwestern California. Bulletin of Association of Engineering Geologists 23:53-60.

Summary: Forest management activities have increased landslide rates in all disturbed watersheds. Inner valley gorges and slopes >80% had the greatest increases.

Woods, P.F. 1980. Dissolved oxygen in intragravel water of three tributaries to Redwood Creek, Humboldt County, California. Water Research Bulletin 16:105-111.

Summary: Intragravel dissolved oxygen was highest in unlogged streams. Unlogged streams also had the lowest percentage of fine sediments.

Wustenberg, D.W. 1954. A preliminary survey of the influences of controlled logging on a trout stream in the H.J. Andrews Experimental Forest, Oregon. M.S. Thesis, Oregon State University. 51 pp.

Summary: Sedimentation greatly increased following logging and was closely associated with road construction. Cutthroat populations were completely eliminated from three tributary streams following logging. Insect populations were affected for one year, and eliminated completely from one section of stream.

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